DOE/NASA CONTRACTOR REPORT

DOE/NASA CR-150704

SOLAR HEAT TRANSPORT FLUID (A Quarterly Report)

Prepared by

Houston Chemical Company
P. O. Box 4026
Corpus Christi, Texas 78408

Under Contract NAS8-32255 with

National Aeronautics and Space Administration
George C. Marshall Space Flight Center, Alabama 35812

For the U. S. Department of Energy

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This work was done under the technical management of Mr. John Caudle, George C. Marshall Space Flight Center, Alabama.

16. ABSTRACT

This report covers the progress made in the development and delivery of noncorrosive fluid subsystems. These subsystems are to be compatible with closed-loop solar heating or combined heating and hot water systems. They are also to be compatible with both metallic and non-metallic plumbing systems. At least 100 gallons of each type of fluid recommended by the contractor will be delivered under the contract. The performance testing of a number of fluids is described.

17. KEY WORDS

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Mgr, Solar Heating and Cooling Project Office

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INTRODUCTION

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SUMMARY

Evaluation and testing of the solar heat transport fluids are continuing. The flow and temperature data have been keypunched and have been processed through the computer problems. Analysis of the data may indicate that some collectors are being cooled more than others. The west wall of the test stand was covered and the systems are being monitored to determine the cooling effect. The Calmac plastic collector has been installed and testing is under way. A combined Prototype Design and Quarterly Review was held at the George C. Marshall Space Flight Center.

OPERATION OF THE SOLAR TEST STAND

Testing of the solar heat transport fluids is continuing on a 24-hour basis.

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Samples of the solar fluids are being taken monthly and analyzed for appearance, pH, and reserve alkalinity. The monthly and composite wet chemistry reports are enclosed.

DATA ORGANIZATION

Modifications have been completed to balance the flow rates between the parallel solar collector panels in a system when the temperature rise across each panel is not equal. The flow and temperature data taken at solar noon have been keypunched, and have been processed through the computer programs. The statistical data is by panel material and solar fluid. Since insolation measurements are not part of this contract, to determine a trend in the performance of solar collectors, a heat flux ratio is calculated based on the ratio of the heat flux of the individual collector panel to the average heat flux for all the solar collector panels.

Analysis from the computer program indicates that some collectors perform better than others. The location of the collectors on the test stand might affect the cooling of those collectors. This difference in cooling effects lowers the collector inlet temperatures, raising the heat flux ratio. The systems containing glycerine and deionized water solution have shown higher heat flux ratios than the other systems. These systems are positioned on the outside west wall, which is exposed to the elements. The west wall of the test stand was covered. The systems are being monitored to determine the effect of covering the west wall.

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The development of a procedure to open the internal passages for corrosion evaluation has been initiated. Copper and aluminum solar collectors which

SOLAR HEAT TRANSPORT FLUIDS
NASA CONTRACT NAS8-32255

pH

System	Material	Fluid	Initial	7/15/77	8/15/77	9/15/77	10/15/77	11/15/77	12/15/77	1/15/78	2/15/78	3/15/78	4/15/78	5/15/78	6/15/78	7/15/78	8/15/78	9/15/78	10/15/78	11/15
1	-	-	9.9										9.7							
2	Cu	P-O	5.2	6.8	8.6	6.5	6.4	6.3	6.6	6.4	6.3	6.1	6.4							
3	Al	P-O	5.2	5.5	4.9	4.9	5.0	5.2	5.0	5.3	5.6	5.6	4.7							
4	Stl	P-O	5.2	5.9	5.1	4.9	5.1	5.1	5.0	5.3	5.8	5.7	4.9							
5	Cu	M-O	7.0	5.9	5.4	5.1	5.1	5.2	5.1	5.2	5.6	5.6	5.0							
6	Al	M-O	7.0	6.3	5.2	5.4	5.2	5.3	5.2	5.2	5.6	5.5	5.3							
7	Stl	M-O	7.0	4.8	4.8	4.9	5.3	5.2	5.0	5.2	5.6	5.4	4.9							
8	Cu	D-W	7.1	8.0	6.8	6.9	7.0	7.1	7.4	6.9	6.6	6.8	6.8							
9	Al	D-W	7.1	8.0	7.6	7.7	7.2	7.1		*7.1	7.0	7.0	7.1							
10	Stl	D-W	7.1	5.6	6.3	6.1	5.9	5.9	5.9	6.1	5.9	5.7	6.4							
11	Cu	G-O	5.5	6.2	5.3	5.1	5.1	5.6	5.1	5.3	5.7	5.6	4.9							
12	Cu	T-1	9.6	9.5	9.8	9.9	10.0	10.1	10.0	10.1	10.1	10.2	10.1							
13	Cu	P-2	9.8	9.8	9.9	9.8	10.0	10.0	9.9	9.9	9.9	9.9	9.9							
14	Cu	P-1	9.8	9.6	9.6	9.5	9.6	9.6	9.6	9.5	9.5	9.5	9.6							
15	Cu	M-4	9.4	9.5	9.4	9.3	9.4	9.4	9.3	9.3	9.3	9.4	9.4							
16	Cu	M-3	9.5	9.4	9.4	9.3	9.4	9.4	9.3	9.3	9.3	9.4	9.4							
17	Cu	M-2	8.8	8.8	8.8	8.8	8.9	8.8	8.8	8.8	8.8	8.8	8.9							
18	Cu	M-1	9.4	9.3	9.2	9.2	9.3	9.2	9.2	9.2	9.2	9.2	9.3							
19	Cu	M-W	8.2	8.0	8.4	8.1	8.2	8.2	8.4	8.5	8.2	8.7	7.9							
20	Al	G-O	5.5	6.1	6.2	7.2	5.3	5.4	6.0	6.0	5.8	5.8	5.7							
21	Al	T-1	9.6	10.1	10.2	10.3	10.5	10.2	10.2	10.2	10.2	10.2	10.1							
22	Al	P-2	9.8	10.2	10.3	10.3	10.4	10.3	10.3	10.3	10.4	10.4	10.5							
23	Al	P-1	9.8	10.3	10.5	10.6	10.6	10.6	10.5	10.7	10.6	10.6	10.5							
24	Al	M-4	9.4	9.4	9.4	9.5	9.5	9.4	9.4	9.4	9.4	9.4	9.4							
25	Al	M-3	9.5	9.5	9.4	9.5	9.5	9.4	9.4	9.7	9.5	9.4	9.4							
26	Al	M-2	8.8	9.2	9.1	9.3	9.3	9.2	9.2	9.3	9.3	9.3	9.3							
27	Al	M-1	9.4	9.3	9.3	9.3	9.3	9.2	9.3	9.3	9.3	9.3	9.3							
28	Al	M-W	8.2	7.8	8.5	8.0	8.5	8.4	9.2	8.4	8.9	8.8	7.7							
29	Stl	G-O	5.5	5.9	5.2	6.6	6.5	5.3	5.7	5.7	5.5	5.5	5.2							
30	Stl	T-1	9.6	9.5	9.8	9.9	10.2	10.2	10.3	10.3	10.4	10.4	10.4							
31	Stl	P-2	9.8	9.8	9.8	9.9	9.9	9.9	9.9	10.0	10.1	10.0	10.0							
32	Stl	P-1	9.8	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6							
33	Stl	M-4	9.4	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3							
34	Stl	M-3	9.5	9.2	9.3	9.2	9.2	9.2	9.2	9.2	9.2	9.3	9.3							
35	Stl	M-2	8.8	9.8	8.8	8.9	8.8	8.9	8.8	8.9	8.9	9.0	8.9							
36	Stl	M-1	9.4	9.3	9.2	9.2	9.2	9.3	9.2	9.2	9.2	9.3	9.1							
37	Stl	M-W	8.2	7.6	8.0	8.1	8.2	8.3	8.4	8.1	8.8	8.6	7.9							
38	Mix	T-2	8.7	-	8.6	8.5	8.7	8.6	8.6	8.6		8.7	8.7							

*New fluid installed

SOLAR HEAT TRANSPORT FLUIDS

NASA CONTRACT NAS8-32255

RESERVE ALKALINITY

System	Material	Fluid	Initial	7/15/77	8/15/77	9/15/77	10/15/77	11/15/77	12/15/77	1/15/78	2/15/78	3/15/78	4/15/78	5/15/78	6/15/78	7/15/78	8/15/78	9/15/78	10/15/78	11/15/78
1													10.830							
2	Cu	P-0																		
3	Al	P-0																		
4	Stl	P-0																		
5	Cu	N-0																		
6	Al	N-0																		
7	Stl	N-0																		
8	Cu	D-W																		
9	Al	D-W																		
10	Stl	D-W																		
11	Cu	C-0																		
12	Cu	T-1	6.10	6.10	6.10	5.90	6.05	5.90	6.00	6.00	6.000	6.000	5.950							
13	Cu	P-2	6.25	6.30	6.20	6.10	6.15	6.10	6.20	6.10	6.100	6.100	6.080							
14	Cu	P-1	6.00	5.95	5.90	5.80	5.90	5.80	5.90	6.00	5.800	5.800	5.830							
15	Cu	N-4	6.65	6.50	6.50	6.50	6.50	6.40	6.50	6.50	6.500	6.500	6.430							
16	Cu	N-3	6.65	6.45	6.50	6.50	6.50	6.40	6.50	6.50	6.400	6.500	6.400							
17	Cu	N-2	11.45	11.30	11.40	11.30	11.35	11.20	11.40	11.30	11.300	11.300	11.330							
18	Cu	N-1	9.90	9.50	9.10	9.10	9.20	9.00	9.10	9.10	9.000	9.900	9.000							
19	Cu	N-W				0.120														
20	Al	C-0																		
21	Al	T-1	6.10	6.00	6.00	6.00	6.00	5.90	6.00	6.00	5.800	5.800	5.880							
22	Al	P-2	6.25	6.20	6.25	6.20	6.23	6.20	6.40	6.30	6.200	6.200	6.130							
23	Al	P-1	6.00	5.90	5.95	5.90	5.90	5.90	5.95	5.90	5.800	5.900	5.800							
24	Al	N-4	6.55	6.60	6.65	6.60	6.70	6.55	6.70	6.60	6.600	6.600	6.530							
25	Al	N-3	6.55	6.60	6.60	6.70	6.65	6.50	6.60	6.60	6.600	6.600	6.480							
26	Al	N-2	11.45	11.50	11.50	11.40	11.50	11.30	11.40	11.50	11.400	11.400	11.350							
27	Al	N-1	9.90	9.90	10.00	9.95	9.90	9.80	9.90	9.90	9.800	9.800	9.780							
28	Al	N-W																		
29	Stl	C-0																		
30	Stl	T-1	6.10	6.10	6.05	6.10	6.05	5.90	6.10	6.00	6.000	6.000	5.950							
31	Stl	P-2	6.25	6.20	6.21	6.30	6.15	6.10	6.30	6.20	6.200	6.200	6.130							
32	Stl	P-1	6.00	5.90	5.90	6.10	5.90	6.00	6.00	5.90	5.900	5.900	5.830							
33	Stl	N-4	6.65	6.60	6.63	6.70	6.65	6.50	6.60	6.60	6.600	6.600	5.550							
34	Stl	N-3	6.65	6.60	6.58	6.60	6.60	6.50	6.60	6.60	6.600	6.600	6.530							
35	Stl	N-2	11.45	11.40	11.24	11.50	11.40	11.25	11.40	11.40	11.300	11.400	11.400							
36	Stl	N-1	9.90	9.90	9.840	9.80	9.85	9.70	9.90	9.90	9.800	9.800	9.700							
37	Stl	N-W																		
38	Mix	T-2	10.6	-	3.23	3.30	3.45	3.10	3.20	3.30	--	3.200	3.050							

NOTE: All blank spaces are <0.100

SOLAR HEAT TRANSPORT FLUID
VISUAL APPEARANCE TEST
NASA CONTRACT NO. 8-32255

System	Fluid	Material	7/15/77	8/15/77	9/15/77	10/15/77	11/15/77	12/15/77	1/15/78	2/15/78	3/15/78	4/15/78
1												100-250
2	P-0	Cu	50-100	50-100	50-100	100-250	0- 50	0- 50	100-250	100-250	100-250	100-250
3	P-0	Al	250-500	250-500	100-250	500 +	250-500	500 +	500 +	250-500	250-500	250-500
4	P-0	Steel	250-500	250-500	250-500	250-500	250-500	250-500	250-500	100-250	100-250	500+
5	M-0	Cu	100-250	100-250	100-250	100-250	100-250	100-250	100-250	100-250	100-250	250-500
6	M-0	Al	250-500	100-250	250-500	250-500	500 +	500 +	500 +	500+	500+	500+
7	M-0	Steel	100-250	250-500	250-500	250-500	250-500	250-500	250-500	100-250	100-250	250-500
8	DW	Cu	50-100	100-250	50-100	0- 50	0- 50	0- 50	0-050	0-050	0-050	0-050
9	DW	Al	0- 50	50-100	0- 50	50-100	0- 50	-	50-100	100-250	100-250	050-100
10	DW	Steel	100-250	100-250	100-250	50-100	50-100	50-100	0-050	0-050	100-250	100-250
11	G-0	Cu	100-250	100-250	100-250	100-250	100-250	100-250	100-250	100-250	050-100	250-500
12	T-1	Cu	100-250	100-250	100-250	100-250	250-500	250-500	500 +	500+	250-500	500+
13	P-2	Cu	50-100	50-100	0- 50	0- 50	0- 50	0- 50	0-050	050-100	050-100	050-100
14	P-1	Cu	100-250	50-100	0- 50	0- 50	0- 50	0- 50	0-050	0-050	050-100	050-100
15	M-4	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	100-250
16	M-3	Cu	50-100	50-100	50-100	0- 50	50-100	0- 50	0-050	050-100	050-100	050-100
17	M-2	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	050-100
18	M-1	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	050-100
19	HW	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	050-100
20	G-0	Al	100-250	100-250	100-250	100-250	100-250	100-250	100-250	050-100	100-250	250-500
21	T-1	Al	100-250	100-250	100-250	100-250	250-500	250-500	500 +	500+	500+	500+
22	P-2	Al	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	0-050	0-050	050-100
23	P-1	Al	0-50	0- 50	50-100	0- 50	0- 50	0- 50	0-050	0-050	0-050	050-100
24	M-4	Al	50-100	50-100	50-100	50-100	50-100	50-100	0-050	050-100	050-100	050-100
25	M-3	Al	50-100	50-100	50-100	0- 50	50-100	0- 50	0-050	050-100	050-100	050-100
26	M-2	Al	50-100	50-100	50-100	0- 50	0- 50	0- 50	0-050	050-100	050-100	050-100
27	M-1	Al	50-100	50-100	50-100	0- 50	0- 50	0- 50	0-050	050-100	050-100	050-100
28	HW	Al	0- 50	50-100	0- 50	50-100	0- 50	0- 50	0-050	0-050	0-050	050-100
29	G-0	Steel	100-250	100-250	100-250	100-250	100-250	100-250	100-250	050-100	100-250	250-500
30	T-1	Steel	50-100	100-250	100-250	100-250	250-500	250-500	500 +	500+	500+	500+
31	P-2	Steel	50-100	50-100	50-100	50-100	50-100	50-100	50-100	100-250	100-250	100-250
32	P-1	Steel	50-100	50-100	50-100	50-100	50-100	50-100	50-100	050-100	050-100	050-100
33	M-4	Steel	50-100	50-100	50-100	100-250	50-100	50-100	50-100	100-250	100-250	100-250
34	M-3	Steel	100-250	100-250	100-250	50-100	100-250	50-100	100-250	100-250	100-250	100-250
35	M-2	Steel	100-250	100-250	100-250	100-250	250-500	100-250	100-250	100-250	100-250	100-250
36	M-1	Steel	100-250	100-250	50-100	50-100	50-100	100-250	100-250	100-250	100-250	250-500
37	DW	Steel	50-100	0- 50	50-100	0- 50	0- 50	0- 50	0-050	050-100	100-250	0-050
38	T-2	Mix	-	100-250	100-250	100-250	100-250	100-250	100-250		250-500	250-500

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INTRODUCTION

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SUMMARY

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Analysis from the computer program indicates that some collectors perform better than others. The location of the collectors on the test stand might affect the cooling of those collectors. This difference in cooling effects lowers the collector inlet temperatures, raising the heat flux ratio. The systems containing glycerine and deionized water solution have shown higher heat flux ratios than the other systems. These systems are positioned on the outside west wall, which is exposed to the elements. The west wall of the test stand was covered. The systems are being monitored to determine the effect of covering the west wall.

SOLAR COLLECTOR PLATE PHYSICAL EVALUATION

The development of a procedure to open the internal passages for corrosion evaluation has been initiated. Copper and aluminum solar collectors which were on stagnation test previous to this contract have been removed from their test stands and samples of their solar fluids are being analyzed. The collector assemblies have been disassembled and their internal passages have been cut open with a band saw. The band saw seems to work satisfactorily for the Rollbond aluminum collector. A visual inspection of the aluminum Rollbond collector showed no visual signs of major corrosion. Samples of the internal flow passage were taken. Examination of the surface and surface composition using X-Ray analysis on the scanning electron microscope is in process. We are only looking at the aluminum collector presently because they are of identical design to the collectors we have on test. The copper collectors are of a tube and plate design. The copper also shows no signs of corrosion. This evaluation will assist in developing a procedure to evaluate the NASA solar collectors.

A sampling procedure seems to be necessary to have a practical outlook on evaluation of the collectors. It is suspected that the inlet area of the collectors internal passages will be the most susceptible area where corrosion will occur. Also, taking selective or random samples might prove to be worthwhile.

TESTING OF NON-METALLIC SYSTEM

We have received delivery of the Calmac non-metallic (EPDM) plastic collector. During installation minor plumbing modifications were necessary which were caused by the position of both the inlet and outlet tubes of the collector as compared to the other collectors. Ethylene glycol with inhibitors and 50% deionized water (M-5) is being tested with this collector.

PROTOTYPE DESIGN AND QUARTERLY REVIEW

In accordance with the management system of this NASA contract a combined Prototype Design and Quarterly Review was held at NASA facility in Huntsville, Alabama. Documentation in accordance with the contract, and as appropriate, was submitted two weeks prior to the review. Those in attendance were:

Kenneth G. Anthony, EP12, NASA
John M. Caudle, FA32, NASA
Thomas S. Homphries, EH24, NASA
John C. Parker, EP14, NASA
Marion L. Roberts, EH43, NASA
John P. Wisnewski, PPG (Houston Chemical Co.)

The Prototype Design review material was presented by the author, the contract manager. A reveiw of solar test stand design, construction and instrumentation were discussed.

An up-to-date test data analysis report was given describing the general trend for assessing corrosion progress by monthly wet chemistry samples. These analyses were described in earlier progress reports which conclude that the appearance and pH data indicate that the systems with uninhibited glycols and glycerine are in an acid environment and have become darker in color. Therefore, corrosion in these systems is probably occurring.

The development of a sampling procedure when evaluating the internal passages of the solar collector plates was discussed.

TEST STAND ENGINEERING

PPG Engineering is supporting the solar project by monitoring test stand installation and by following up on engineering items such as drawing changes.

SOLAR PUMP TESTS

The Grundfos pump is still running on a continuous closed loop test.

SCHEDULE

A program schedule is attached and is layed out to show the actual work performed.

EXPENDITURES

This information has been deleted.

NEXT REPORTING PERIOD

1. Sample all solar heat transport fluids every 30 days and evaluate them for deterioration and general performance by appearance, pH and reserve alkalinity analysis. Additional analysis for ash content, foaming, and viscosity will be made if a solar collector panel fails or at the end of the test period, whichever occurs first.

2. Develop procedures to determine when a solar collector panel fails and determine how to open collector panel internal passages for examination and determination of the corrosion rate.

3. Evaluate computer programs which organize the solar temperature and flow data to determine solar collector performance.

4. Operate the solar test stand.

Sincerely,

John P. Wisnewski
Project Manager

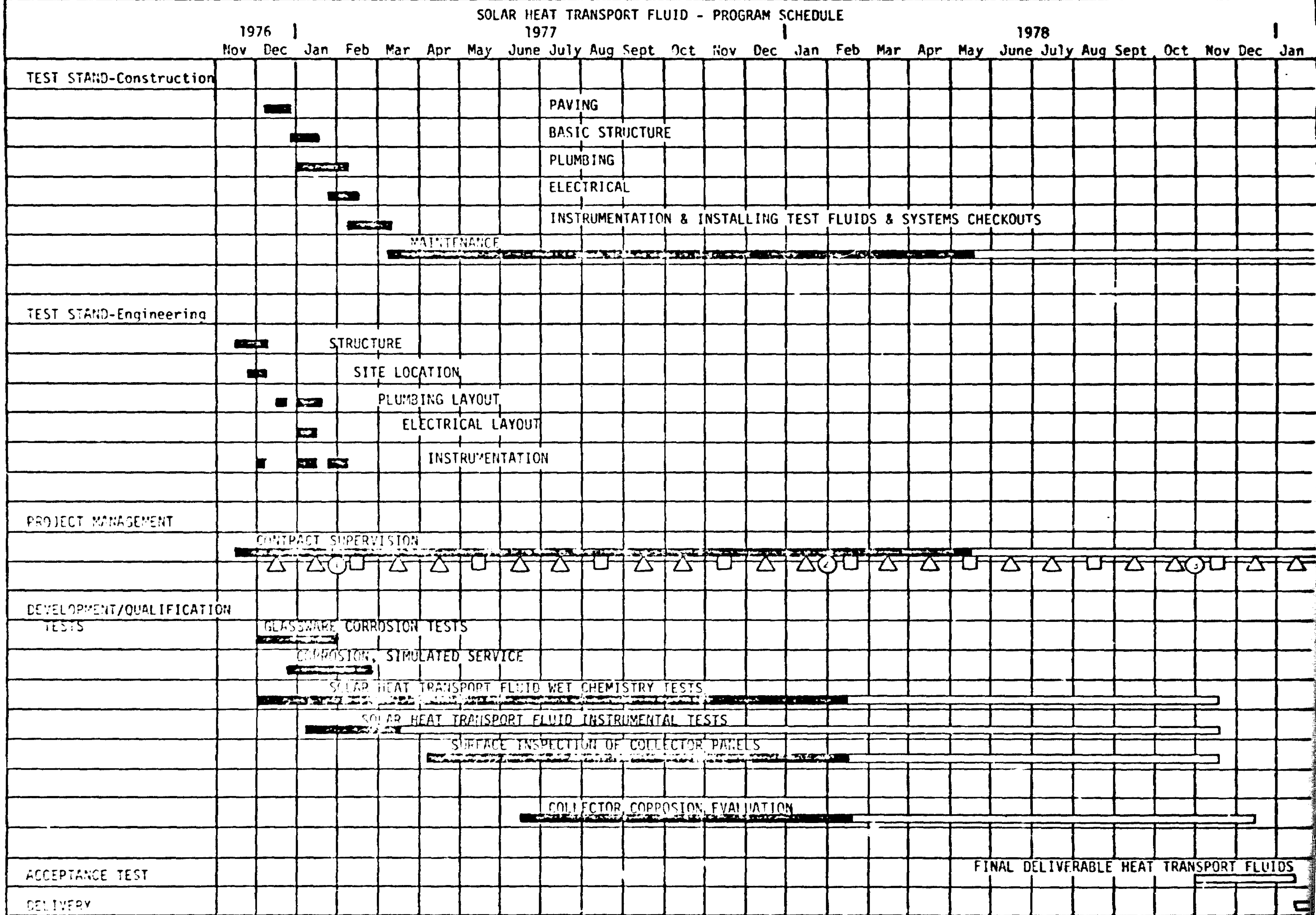
bj

Enclosures

ORIGINAL PAGE IS
OF POOR QUALITY

HOUSTON CHEMICAL COMPANY

Contract No. NAS8-32255



LEGEND

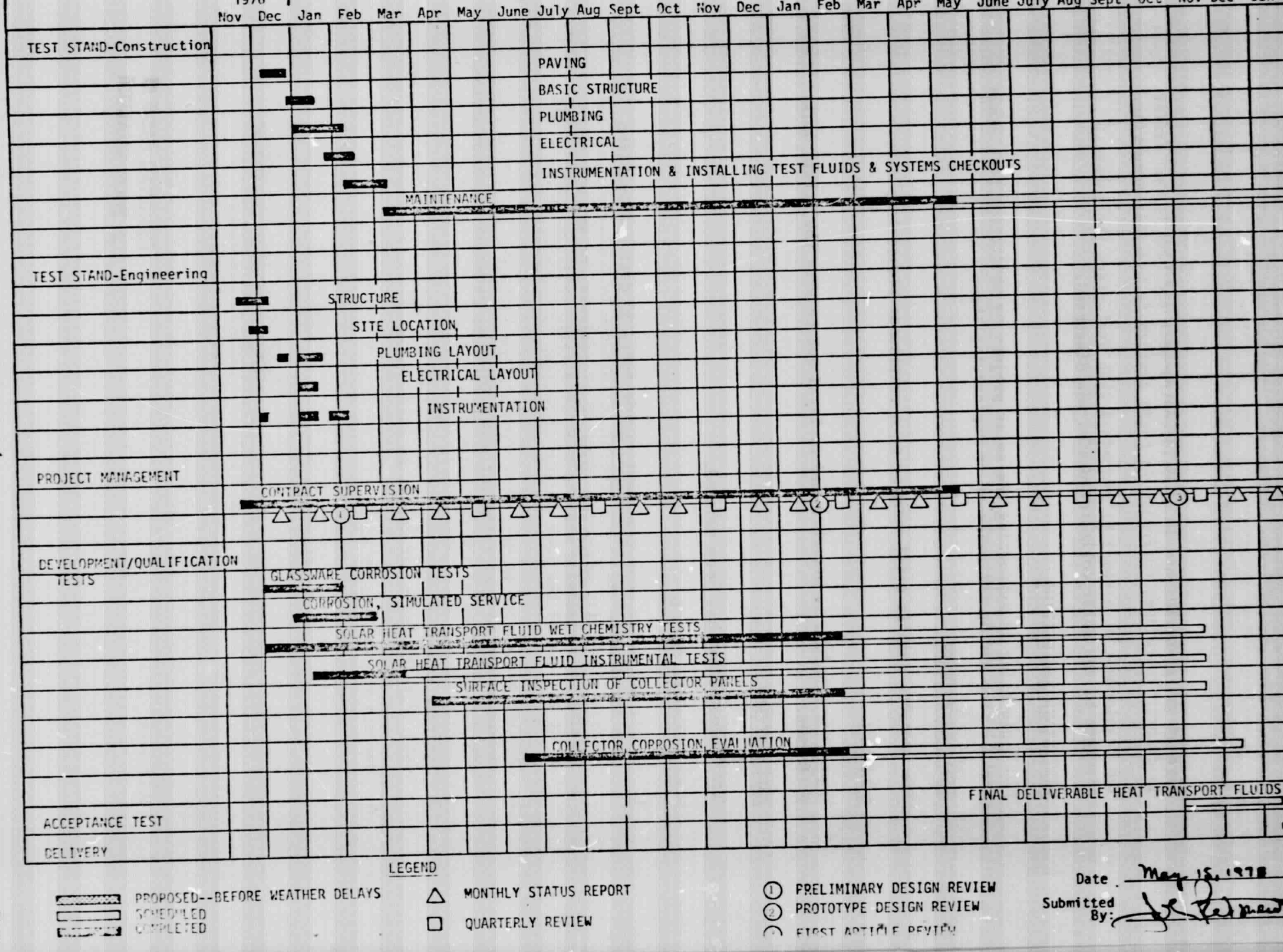
PROPOSED--BEFORE WEATHER DELAYS
SCHEDULED
COMPLETED

△ MONTHLY STATUS REPORT
□ QUARTERLY REVIEW

① PRELIMINARY DESIGN REVIEW
② PROTOTYPE DESIGN REVIEW
③ FIRST ARTICLE REVIEW

Date May 15, 1978

Submitted By: [signature]


1978
Nov Dec Jan Feb Mar Apr May June July Aug Sept Oct Nov Dec Jan Feb Mar Apr May June July Aug Sept
TEST STAND-Construction
PAVING
BASIC STRUCTURE
PLUMBING
ELECTRICAL
INSTRUMENTATION & INSTALLING TEST FLUIDS & SYSTEMS CHECKOUTS
MAINTENANCE
TEST STAND-Engineering
STRUCTURE
SITE LOCATION
PLUMBING LAYOUT
ELECTRICAL LAYOUT
INSTRUMENTATION
PROJECT MANAGEMENT
CONTRACT SUPERVISION
DEVELOPMENT/QUALIFICATION TESTS
GLASSWARE CORROSION TESTS
CORROSION, SIMULATED SERVICE
SOLAR HEAT TRANSPORT FLUID WET CHEMISTRY TESTS
SOLAR HEAT TRANSPORT FLUID INSTRUMENTAL TESTS
SURFACE INSPECTION OF COLLECTOR PANELS
COLLECTOR CORROSION EVALUATION
FINAL DELIVERABLE HEAT TRANSPORT FLUIDS
ACCEPTANCE TEST
DELIVERY
LEGEND
PROPOSED--BEFORE WEATHER DELAYS
SCHEDULED
COMPLETED
MONTHLY STATUS REPORT
QUARTERLY REVIEW
1 PRELIMINARY DESIGN REVIEW
2 PROTOTYPE DESIGN REVIEW
3 FIRST ARTICLE REVIEW
Date May 15, 1978
Submitted By:

FLUID TABLE

Fluid	Fluid Description
D-W	Deionized Water
H-W	Hard Water
M-0	Monoethylene Glycol
M-1	Monoethylene Glycol
M-2	Monoethylene Glycol
M-3	Monoethylene Glycol
M-4	Monoethylene Glycol
G-0	Glycerine
P-0	Propylene Glycol
P-1	Propylene Glycol
P-2	Propylene Glycol
T-1	Triethylene Glycol
T-2	Triethylene Glycol

SYSTEM	MAT.	FLUID	CONC. PCT.	ORIG. PH	PRES. PH	ORIGINAL RES.ALK.	PRESENT RES.ALK.	APPEAR
1	EPDM	M-5	50.0	9.9	9.7	10.750	10.830	100-250
2	CU	P-O	45.9	5.2	6.4	LT 0.100	LT 0.100	100-250
3	AL	P-O	50.6	5.2	4.7	LT 0.100	LT 0.100	250-500
4	STL	P-O	50.3	5.2	4.9	LT 0.100	LT 0.100	500+
5	CU	M-O	49.5	7.0	5.0	LT 0.100	LT 0.100	250-500
6	AL	M-O	50.7	7.0	5.3	LT 0.100	LT 0.100	500+
7	STL	M-O	49.6	7.0	4.9	LT 0.100	LT 0.100	250-500
8	CU	D-W	100.0	7.1	6.8	LT 0.100	LT 0.100	000-050
9	AL	D-W	100.0	7.1	7.1	LT 0.100	LT 0.100	050-100
10	STL	D-W	100.0	7.1	6.4	LT 0.100	LT 0.100	100-250
11	CU	G-O	59.3	5.5	4.9	LT 0.100	LT 0.100	250-500
12	CU	T-1	50.5	9.6	10.1	6.100	5.950	500+
13	CU	P-2	50.9	9.8	9.9	6.250	6.080	050-100
14	CU	P-1	50.9	9.8	9.6	6.000	5.800	050-100
15	CU	M-4	50.3	9.4	9.4	6.650	6.430	100-250
16	CU	M-3	50.3	9.5	9.4	6.650	6.400	050-100
17	CU	M-2	51.5	8.8	8.9	11.450	11.330	050-100
18	CU	M-1	47.7	9.4	9.3	9.900	9.000	050-100
19	CU	H-W	100.0	8.2	7.9	LT 0.100	LT 0.100	050-100
20	AL	G-O	59.5	5.5	5.7	LT 0.100	LT 0.100	250-500
21	AL	T-1	50.5	9.6	10.1	6.100	5.880	500+
22	AL	P-2	51.6	9.8	10.3	6.250	6.130	050-100
23	AL	P-1	51.3	9.8	10.5	6.000	5.800	050-100
24	AL	M-4	51.2	9.4	9.4	6.550	6.530	050-100

SYSTEM	MAT.	FLUID	CONC. PCT.	ORIG. PH	PRES. PH	ORIGINAL RES.ALK.	PRESENT RES.ALK.	APPEAR
25	AL	M-3	51.2	9.5	9.4	6.550	6.480	050-100
26	AL	M-2	51.5	8.8	9.3	11.450	11.350	050-100
27	AL	M-1	51.5	9.4	9.3	9.900	9.780	050-100
28	AL	H-W	100.0	8.2	7.7	LT 0.100	LT 0.100	050-100
29	STL	G-O	59.5	5.5	5.2	LT 0.100	LT 0.100	250-500
30	STL	T-1	51.0	9.6	10.4	6.100	5.950	500+
31	STL	P-2	51.7	9.8	10.0	6.250	6.130	100-250
32	STL	P-1	51.8	9.8	9.6	6.000	5.830	050-100
33	STL	M-4	51.6	9.4	9.3	6.650	6.550	100-250
34	STL	M-3	51.6	9.5	9.3	6.650	6.530	100-250
35	STL	M-2	52.0	8.8	8.9	11.450	11.400	100-250
36	STL	M-1	51.3	9.4	9.1	9.900	9.700	250-500
37	STL	H-W	100.0	8.2	7.9	0.100	LT 0.100	000-050
38	MIX	T-2	34.4	8.7	8.7	10.600	3.050	250-500

SOLAR HEAT TRANSPORT FLUIDS
NASA CONTRACT NAS8-32255

pH

System	Material	Fluid	Initial	7/15/77	8/15/77	9/15/77	10/15/77	11/15/77	12/15/77	1/15/78	2/15/78	3/15/78	4/15/78	5/15/78	6/15/78	7/15/78	8/15/78	9/15/78	10/15/78	11/15
1	-	-	9.9										9.7							
2	Cu	P-0	5.2	6.8	6.6	6.5	6.4	6.3	6.6	6.4	6.3	6.1	6.4							
3	Al	P-0	5.2	5.5	4.9	4.9	5.0	5.2	5.0	5.3	5.6	5.6	4.7							
4	Stl	P-0	5.2	5.9	5.1	4.9	5.1	5.1	5.0	5.3	5.8	5.7	4.9							
5	Cu	M-0	7.0	5.9	5.4	5.1	5.1	5.2	5.1	5.2	5.6	5.6	5.0							
6	Al	M-0	7.0	6.3	5.2	5.4	5.2	5.3	5.2	5.2	5.6	5.5	5.3							
7	Stl	M-0	7.0	4.8	4.8	4.9	5.3	5.2	5.0	5.2	5.6	5.4	4.9							
8	Cu	D-W	7.1	8.0	6.8	6.9	7.0	7.1	7.4	6.9	6.6	6.8	6.8							
9	Al	D-W	7.1	8.0	7.6	7.7	7.2	7.1		*7.1	7.0	7.0	7.1							
10	Stl	D-W	7.1	5.6	6.3	6.1	5.9	5.9	5.9	6.1	5.9	5.7	6.4							
11	Cu	G-0	5.5	6.[illegible]	5.3	5.1	5.1	5.6	5.1	5.3	5.7	5.6	4.9							
12	Cu	T-1	9.6	9.5	9.8	9.9	10.0	10.1	10.0	10.1	10.1	10.2	10.1							
13	Cu	P-2	9.8	9.8	9.9	9.8	10.0	10.0	9.9	9.9	9.9	9.9	9.9							
14	Cu	P-1	9.8	9.6	9.6	9.5	9.5	9.6	9.6	9.5	9.5	9.5	9.6							
15	Cu	M-4	9.4	9.5	9.4	9.3	9.4	9.4	9.3	9.3	9.3	9.4	9.4							
16	Cu	M-3	9.5	9.4	9.4	9.3	9.4	9.4	9.3	9.3	9.3	9.4	9.4							
17	Cu	M-2	8.8	8.8	8.8	8.8	8.9	8.8	8.8	8.8	8.8	8.8	8.9							
18	Cu	M-1	9.4	9.3	9.2	9.2	9.3	9.2	9.2	9.2	9.2	9.2	9.[illegible]							
19	Cu	M-W	8.2	8.0	8.4	8.1	8.2	8.2	8.4	8.5	8.2	8.7	7.9							
20	Al	G-0	5.5	6.1	6.2	7.2	5.3	5.4	6.0	6.0	5.8	5.8	5.7							
21	Al	T-1	9.6	10.1	10.2	10.3	10.5	10.2	10.2	10.2	10.2	10.2	10.1							
22	Al	P-2	9.8	10.2	10.3	10.3	10.4	10.3	10.3	10.3	10.4	10.4	10.3							
23	Al	P-1	9.8	10.3	10.5	10.6	10.6	10.6	10.5	10.7	10.6	10.6	10.5							
24	Al	M-4	9.4	9.4	9.4	9.5	9.5	9.4	9.4	9.4	9.4	9.4	9.4							
25	Al	M-3	9.5	9.5	9.4	9.5	9.5	9.4	9.4	9.7	9.5	9.4	9.4							
26	Al	M-2	8.8	9.1	9.1	9.3	9.3	9.2	9.2	9.3	9.3	9.3	9.3							
27	Al	M-1	9.4	9.3	9.3	9.3	9.3	9.2	9.3	9.3	9.3	9.3	9.3							
28	Al	M-W	8.2	7.8	8.5	8.0	8.5	8.4	9.2	8.4	8.9	8.8	7.7							
29	Stl	G-0	5.5	5.9	5.2	6.6	6.5	5.3	5.[illegible]	5.7	5.5	5.5	5.2							
30	Stl	T-1	9.6	9.5	9.8	9.9	10.2	10.2	10.3	10.3	10.4	10.4	10.4							
31	Stl	P-2	9.8	9.8	9.8	9.9	9.9	9.9	9.9	10.0	10.1	10.0	10.0							
32	Stl	P-1	9.8	9.6	9.6	9.5	9.6	9.6	9.6	9.6	9.6	9.6	9.6							
33	Stl	M-4	9.4	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3	9.3							
34	Stl	M-3	9.5	9.2	9.3	9.2	9.2	9.2	9.2	9.2	9.2	9.3	9.3							
35	Stl	M-2	8.8	9.8	8.8	8.9	8.8	8.9	8.8	8.9	8.9	9.0	8.9							
36	Stl	M-1	9.4	9.3	9.2	9.2	9.2	9.[illegible]	9.2	9.2	9.2	9.3	9.1							
37	Stl	M-W	8.2	7.6	8.0	8.1	8.2	8.3	8.4	8.1	8.8	8.6	7.9							
38	Mix	T-2	8.7	-	8.6	8.5	8.7	8.6	8.6	8.6		8.7	8.7							

*New fluid installed

SOLAR HEAT TRANSPORT FLUIDS

NASA CONTRACT NAS8-32255

RESERVE ALKALINITY

System	Material	Fluid	Initial	7/15/77	8/15/77	9/15/77	10/15/77	11/15/77	12/15/77	1/15/78	2/15/78	3/15/78	4/15/78	5/15/78	6/15/78	7/15/78	8/15/78	9/15/78	10/15/78	11/15/78
1													10.830							
2	Cu	P-O																		
3	Al	P-O																		
4	Stl	P-O																		
5	Cu	N-O																		
6	Al	N-O																		
7	Stl	N-O																		
8	Cu	D-W																		
9	Al	D-W																		
10	Stl	D-W																		
11	Cu	G-O																		
12	Cu	T-1	6.10	6.10	6.10	5.90	6.05	5.90	6.00	6.00	6.000	6.000	5.950							
13	Cu	P-2	6.25	6.30	6.20	6.10	6.15	6.10	6.20	6.10	6.100	6.100	6.080							
14	Cu	P-1	6.00	5.95	5.90	5.80	5.90	5.80	5.90	6.00	5.800	5.800	5.800							
15	Cu	N-4	6.65	6.50	6.50	6.50	6.50	6.40	6.50	6.50	6.500	6.500	6.430							
16	Cu	N-3	6.65	6.45	6.50	6.50	6.50	6.40	6.50	6.50	6.400	6.500	6.400							
17	Cu	N-2	11.45	11.30	11.40	11.30	11.35	11.20	11.40	11.30	11.300	11.300	11.330							
18	Cu	N-1	9.90	9.50	9.10	9.10	9.20	9.00	9.10	9.10	9.000	9.900	9.000							
19	Cu	H-W				0.120														
20	Al	G-O																		
21	Al	T-1	6.10	6.00	6.00	6.00	6.00	5.90	6.00	6.00	5.800	5.800	5.880							
22	Al	P-2	6.25	6.20	6.25	6.20	6.23	6.20	6.40	6.30	6.200	6.200	6.130							
23	Al	P-1	6.00	5.90	5.95	5.90	5.90	5.90	5.95	5.90	5.800	5.900	5.800							
24	Al	N-4	6.55	6.60	6.65	6.60	6.70	6.55	6.70	6.60	6.600	6.600	6.530							
25	Al	N-3	6.55	6.60	6.60	6.70	6.65	6.50	6.60	6.60	6.600	6.600	6.480							
26	Al	N-2	11.45	11.50	11.50	11.40	11.50	11.30	11.40	11.50	11.400	11.400	11.350							
27	Al	N-1	9.90	9.90	10.00	9.95	9.90	9.80	9.90	9.90	9.800	9.800	9.780							
28	Al	H-W																		
29	Stl	G-O																		
30	Stl	T-1	6.10	6.10	6.05	6.10	6.05	5.90	6.10	6.00	6.000	6.000	5.950							
31	Stl	P-2	6.25	6.20	6.21	6.30	6.15	6.10	6.30	6.20	6.200	6.200	6.130							
32	Stl	P-1	6.00	5.90	5.90	6.10	5.90	6.00	6.00	5.90	5.900	5.900	5.830							
33	Stl	N-4	6.65	6.60	6.63	6.70	6.65	6.50	6.60	6.60	6.600	6.600	5.550							
34	Stl	N-3	6.65	6.60	6.58	6.60	6.60	6.50	6.60	6.60	6.600	6.600	6.530							
35	Stl	N-2	11.45	11.40	11.24	11.50	11.40	11.25	11.40	11.40	11.300	11.400	11.400							
36	Stl	N-1	9.90	9.90	9.840	9.80	9.85	9.70	9.90	9.90	9.800	9.800	9.700							
37	Stl	H-W																		
38	Mix	T-2	10.6	-	3.23	3.30	3.45	3.10	3.20	3.30	--	3.200	3.050							

NOTE: All blank spaces are <0.100

SOLAR HEAT TRANSPORT FLUID
VISUAL APPEARANCE TEST
NASA CONTRACT NO. 8-32255

System	Fluid	Material	7/15/77	8/15/77	9/15/77	10/15/77	11/15/77	12/15/77	1/15/78	2/15/78	3/15/78	4/15/78
1												100-250
2	P-0	Cu	50-100	50-100	50-100	100-250	0- 50	0- 50	100-250	100-250	100-250	100-250
3	P-0	Al	250-500	250-500	100-250	500 +	250-500	500 +	500 +	250-500	250-500	250-500
4	P-0	Steel	250-500	250-500	250-500	250-500	250-500	250-500	250-500	100-250	100-250	500+
5	M-0	Cu	100-250	100-250	100-250	100-250	100-250	100-250	100-250	100-250	100-250	250-500
6	M-0	Al	250-500	100-250	250-500	250-500	500 +	500 +	500 +	500+	500+	500+
7	M-0	Steel	100-250	250-500	250-500	250-500	250-500	250-500	250-500	100-250	100-250	250-500
8	DW	Cu	50-100	100-250	50-100	0- 50	0- 50	0- 50	0-050	0-050	0-050	0-050
9	DW	Al	0- 50	50-100	0- 50	50-100	0- 50	-	50-100	100-250	100-250	050-100
10	DW	Steel	100-250	100-250	100-250	50-100	50-100	50-100	0-050	0-050	100-250	100-250
11	G-0	Cu	100-250	100-250	100-250	100-250	100-250	100-250	100-250	100-250	050-100	250-500
12	T-1	Cu	100-250	100-250	100-250	100-250	250-500	250-500	500 +	500+	250-500	500+
13	P-2	Cu	50-100	50-100	0- 50	0- 50	0- 50	0- 50	0-050	050-100	050-100	050-100
14	P-1	Cu	100-250	50-100	0- 50	0- 50	0- 50	0- 50	0-050	0-050	050-100	050-100
15	M-4	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	100-250
16	M-3	Cu	50-100	50-100	50-100	0- 50	50-100	0- 50	0-050	050-100	050-100	050-100
17	M-2	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	050-100
18	M-1	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	050-100
19	HW	Cu	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	050-100	050-100	050-100
20	G-0	Al	100-250	100-250	100-250	100-250	100-250	100-250	100-250	050-100	100-250	250-500
21	T-1	Al	100-250	100-250	100-250	100-250	250-500	250-500	500 +	500+	500+	500+
22	P-2	Al	50-100	50-100	50-100	50-100	0- 50	0- 50	0-050	0-050	0-050	050-100
23	P-1	Al	0-50	0- 50	50-100	0- 50	0- 50	0- 50	0-050	0-050	0-050	050-100
24	M-4	Al	50-100	50-100	50-100	50-100	50-100	50-100	0-050	050-100	050-100	050-100
25	M-3	Al	50-100	50-100	50-100	0- 50	50-100	0- 50	0-050	050-100	050-100	050-100
26	M-2	Al	50-100	50-100	50-100	0- 50	0- 50	0- 50	0-050	050-100	050-100	050-100
27	M-1	Al	50-100	50-100	50-100	0- 50	0- 50	0- 50	0-050	050-100	050-100	050-100
28	HW	Al	0- 50	50-100	0- 50	50-100	0- 50	0- 50	0-050	0-050	0-050	050-100
29	G-0	Steel	100-250	100-250	100-250	100-250	100-250	100-250	100-250	050-100	100-250	250-500
30	T-1	Steel	50-100	100-250	100-250	100-250	250-500	250-500	500 +	500+	500+	500+
31	P-2	Steel	50-100	50-100	50-100	50-100	50-100	50-100	50-100	100-250	100-250	100-250
32	P-1	Steel	50-100	50-100	50-100	50-100	50-100	50-100	50-100	050-100	050-100	050-100
33	M-4	Steel	50-100	50-100	50-100	100-250	50-100	50-100	50-100	100-250	100-250	100-250
34	M-3	Steel	100-250	100-250	100-250	50-100	100-250	50-100	100-250	100-250	100-250	100-250
35	M-2	Steel	100-250	100-250	100-250	100-250	250-500	100-250	100-250	100-250	100-250	100-250
36	M-1	Steel	100-250	100-250	50-100	50-100	50-100	100-250	100-250	100-250	100-250	250-500
37	HW	Steel	50-100	0- 50	50-100	0- 50	0- 50	0- 50	0-050	050-100	100-250	0-050
38	T-2	Mix	-	100-250	100-250	100-250	100-250	100-250	100-250		250-500	250-500

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NASA—MSFC